# APPLICATION
# FOR
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# LETTERS PATENT

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      INFORMATION PRESENTATION
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# EYE GAZE CONTROL OF DYNAMIC
# INFORMATION PRESENTATION

## DESCRIPTION

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## BACKGROUND OF THE INVENTION

### *Field of the Invention*

10      The present invention generally relates to a system for scrolling a screen and, more particularly, to a system for scrolling an image on a computer display screen based on eye movements.

### *Description of the Related Art*

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Eye tracking systems can determine where on a computer screen the user is looking and they have been used as the primary input device of computers, replacing both the keyboard and the mouse. Thus, such systems are able to
20      control all processes of a computer that do not require response times that are too short to be provided via eye movements and software constraints. Since these systems do not require any force or the use of any movements other than
25      the eyes, they are appealing for use by people who are unable to use conventional devices.

While eye trackers can enable human-computer interaction using only the eyes, there are many reasons that such interaction can be difficult, frustrating, and

tiresome.  First, people do not normally consciously control their eye movements.  Furthermore, people are not accustomed to changing their visual environment simply by looking at it.  Another reason is that the accuracy of eye position information is limited to the angle of foveation, which is about 1 degree. This angle describes the portion of the visual field that falls entirely on the high resolution part of the retina, called the fovea. Since everything projected onto the fovea is high resolution, it is unnecessary to move the eye to evaluate foveated objects. Consequently, special techniques must be employed to improve the specificity of eye gaze information (such as enlarging an area that has been dwelled upon). Finally, eye gaze information is limited to cursor or screen position, which leads to very cumbersome styles of interaction.

Conversely, most input devices are able to convey both the action (e.g., left/right mouse click) and the object of the action (e.g., the graphical construct underneath the mouse cursor). To distinguish between an action and the object, eye trackers either use a secondary input, such as a sip-and-puff switch, or they distinguish between eye movement and eye dwell. Moving the eye to a particular screen location and dwelling there indicates the object and the desire to perform an action. This can produce a dialog window with buttons indicating the desired action, which can then be selected by looking at them and dwelling upon them. However, this results in an unnatural, slow, and cumbersome means of controlling the computer.

Reading text and navigating through information on computer screens can be difficult even when using

conventional input devices and interaction idioms, like dragging the tab on a window scroll bar. This is made even more difficult when the user is unable to use conventional devices and must use alternatives, like eye tracking

5 systems.

The challenge, therefore, is to make reading text and navigating through scrollable information easier and more natural. Scrollable information includes any information that is discretized into individual units and can be

10 displayed sequentially. Examples of navigating through scrollable information include reading text, searching through thumbnail images, perusing the columns or rows of a spreadsheet, etc.

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## SUMMARY OF THE INVENTION

The invention uses eye gaze information from an eye gaze tracking system to continuously control the rate and

20 direction of scrollable information presentation in a natural manner. Initially, images begin scrolling on the display at an initial rate. An eye tracking device is used to determine the area on the display that the user is looking. For example, consider the case of text scrolling on

25 the display from bottom to top at an initial rate. If the users eyes remain fixed near the vertical middle of the display, reading left to right, this indicates that the text is scrolling at a comfortable speed for the user to read the text. Alternatively, if the user's eyes begin to drift up

30 towards the top of the screen, this indicates that the text

is scrolling too fast and the user is not keeping up. In this case, this shift in eye position is detected by the eye tracking device and the scroll rate is automatically reduced to a more comfortable rate for the user. If the users's eyes are reading too close to the top of the display, the scroll direction may actually be reversed so that the line being read is more centered in the display. Conversely, if the eye tracker detects that the user's eyes are drifting towards the bottom of the display, this indicates that the user is reading faster than the information is being presented and the scroll rate is automatically increased to a more comfortable rate.

In short, the present invention controls the rate of progression and the direction of progression through the information and it does so continuously based on the relationship between the text display and the position of the eyes. It uses a negative feedback system for natural control and it extracts the control information unobtrusively during the process of reading or information perusal. Explicit and secondary control gestures, such as eye dwell or sip-and-puff devices are not required.


**BRIEF DESCRIPTION OF THE DRAWINGS**

The foregoing and other objects, aspects and advantages will be better understood from the following detailed description of a preferred embodiment of the invention with reference to the drawings, in which:

Figure 1 is a diagram showing the basic set up of the

eye gaze control system according to the present invention;

Figure 2 is a screen illustrating automatic scroll rate; and

Figure 3 is a flow diagram illustrating the steps for automatically controlling the display scroll rate according to gaze position.

## DETAILED DESCRIPTION OF A PREFERRED
## EMBODIMENT OF THE INVENTION

Referring now to the drawings, and more particularly to Figure 1 there is shown a typical set up for the present invention. A display monitor 10 is connected to a computer 12 and positioned in front of a user 14. Traditional input devices such as a keyboard 16 or mouse (not shown) may also be present. However, in certain situations, the user may have physical constraints that render them unable to use traditional input devices. Therefore, the present invention provides an alternative to these traditional devices and would be useful for any individual capable of moving his or her eyes, including a quadriplegic or similarly disabled person.

In particular, an eye gaze tracker 18 is mounted and aimed such that the user's eyes 22 are in its field of vision 20. Suitable eye tracking devices or cameras are well known in the art. The purpose of eye gaze trackers, also called eye trackers, is to determine where an individual is looking. The primary use of the technology is as an input device for human-computer interaction. In such a capacity, eye trackers enable the computer to determine where on the

computer screen the individual is looking. The most
effective and common eye tracking technology exploits the
"bright-eye" effect. The bright-eye effect is familiar to
most people as the glowing red pupils observed in
photographs of people taken with a flash that is mounted
near the camera lens. In the case of eye trackers, the eye
is illuminated with infrared light, which is not visible to
the human eye. An Infrared camera can easily detect the
infrared light re-emitted by the retina. It can also detect
the even brighter primary reflection of the infrared
illuminator off of the front surface of the eye. The
relative position of the primary reflection to the large
circle caused by the light re-emitted by the retina (the
bright-eye effect) can be used to determine the direction of
gaze. This information, combined with the relative positions
of the camera 18, the eyes 22, and the computer display 10,
can be used to compute where on the computer screen the user
14 is looking 24.

The invention uses eye gaze information from an eye
gaze tracking system to continuously control the rate and
direction of scrollable information presentation in a
natural manner. The invention may be applied to text or
information that scrolls in any direction, such as
vertically or horizontally.

Referring to Figure 2, this description will assume
that the scrollable information is text and that it scrolls
vertically from the bottom to top of a text window as
indicated by arrow 30 (the vertical scroll bar 32 moves from
top to bottom). This, however, is not a requirement as the
invention applies to other types of information and

multiples styles of scrolling.

Groups of text appear at the bottom of the text window and appear to move up the screen at an initial rate. If the eye gaze is near the center 34 of the text window then the rate of text movement does not change. This is consistent with the reader being able to assimilate the text at exactly the same rate as it is being presented. If the text is being presented too fast, then the reader will tend to follow a group of text past the center of the text window, say to point 36. Thus, when the eye gaze moves above the center of the screen, the rate of text presentation will automatically slow down. Similarly, if the text is being presented too slowly, the reader will tend to read ahead. This corresponds to moving the eye gaze below the center of the text window, say to point 38. Thus, the invention will increase the rate of text presentation when the eye gaze moves below the center of the text window. In this manner, the rate of information presentation will automatically adjust to the rate at which it is being assimilated.

As a variation, this rate adjustment mechanism need not be anchored to the center of the window 34. The anchor location can dynamically adjust itself to the position of eye gaze dwell. Thus, the rate remains constant as long as the eye does not move up or down. If it moves down, the invention increases the rate of information presentation; if it moves up, the invention decreases the rate of information presentation. In this manner, the rate at which information is presented depends only on the vertical location of the eye gaze. When the eye gaze is at the top of the window the rate of information presentation is low and the rate is very

high near the bottom of the window.

As the eye gaze approaches the top of the window, the rate of text presentation will decrease until the eye gaze reaches the point 40 at which the direction of information presentation reverses. At this point, the effect of eye gaze position is reversed. At the top of the window, the rate of reverse information presentation (an downward motion) is at its highest. As the eye gaze approaches the center of the window 34 the reverse rate slows until it gets high enough that the direction reverses again. At this point, the information will once again flow from the bottom to the top.

To decrease the flow rate discontinuity at the direction reversals, a transient effect can be added. This transient effect will tend to slow down the rate, but its effect will diminish with time. Thus, a reversal from upward motion to downward motion will be slow enough that the eye can adjust and follow the information. During this transient, the eye can move to the vertical position that corresponds to the rate at which information can be assimilated. Soon the transient effect dissipates and normal behavior resumes.

Figure 3 is a flow diagram outlining the above procedure. Once the system is started 50, text or other display objects begin to scroll at an initial scroll rate 52, perhaps one line every 5-10 seconds. In the preferred embodiment the scrolling is a smooth continuous motion. The computer 12, via the eye gaze tracker 18, computes the user's gaze position 54 and compares it to an anchor point. As shown in Figure 2, the anchor point can be any point where the user is comfortable reading but for illustration

purposes is initially set to be at the horizontal line in the at the vertical center 34 of the display. In decision block 56, if the user is determined to be gazing at the anchor point, the scroll rate remains unchanged. If, in decision block 58, it is determined that the user's gaze is drifting below the anchor point (e.g., point 38 in Figure 2), the scroll rate is increased at block 60 since this indicates that the text is being presented too slowly and the user is reading ahead. Similarly, is at decision block 62, if it is determined that the user is gazing above the anchor point (e.g., point 36 in Figure 2), the scroll rate is automatically decreased at block 64 since this indicates that the text is being presented faster than the reader read. If at decision block 66 it is determined that the user is gazing very near the top of the screen, the scroll direction is reversed at block 68 since in this situation it is likely that some of the text has scrolled off of the screen prior being read.

The invention has been described in terms of items scrolling from bottom to top, since this is the typical manner in scrolling items are read. However, one skilled in the art will recognize that the teachings set forth are equally as valid for text scrolling from top to bottom simply by interchanging the points at which the scroll rate is increased or decreased. Similarly, horizontal scrolling rates can also be automatically adjusted by determining the users gaze position relative to the left and right sides of the screen.

The invention may be applied to text or information that scrolls in any direction, such as vertically or

horizontally. This description assumed that the scrollable
information is text and that it scrolls vertically from the
top to the bottom of a text window. This, however, is not a
requirement as the invention applies to other types of

5      information and multiples styles of scrolling. In addition,
this invention is preferably embodied in software stored in
any suitable machine readable medium such as magnetic or
optical disk, network server, etc., and intended to be run
of course on a computer equipped with the proper hardware

10     including an eye gaze tracker and display.